A **POGIL inspired** student-developed **teaching resource** (***"Using Roman Pigments to Teach Heritage Science"***) to support **Chemistry** pupils by using sequential game-based, small-group problem-solving exercises, underpinned by genuine **Archaeological** research

University of Glasgow

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OUTLINE

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- What is **POGIL**?
- **Our project aims (PTU = P**OGIL **T**eaching **U**nit)
- Our **planning** and **development** of PTU
- Example of a **POGIL exercise**
- Pilot & Evaluation & Summary of PTU

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POGIL: **P**rocess **O**rientated **G**uided **I**nquiry **L**earning

- **student-centred** learning pedagogical technique
- **Small-group** teams
- **Instructor facilitates** collaborative learning process
- **Constructivist approach**: teams are led sequentially through a series of exercises to support **concept assembly** and to reach the **appropriate conclusions**
- Originally developed for chemistry, *POGIL can be used across many disciplines* to **support the development and learning of key concepts**.
- develops desired *process skills* (**problem-solving** and **deductive-reasoning)**
- enhances **higher-order learning** and improves **confidence**.

Our Aims: Project & Talk

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- **Project Aims:**
  - Creation of an innovative outreach teaching resource to engage and support AH Chem
    - Support SQA Curriculum
    - Career Support
    - Undertake Scholarship (develop, deploy, evaluate, and disseminate)
- A series of **game-based** exercises to identify “mystery” pigments, mimicking real-life approaches
  - to *improve knowledge & ability* and
  - *to improve confidence* in **problem-solving**.
- **Talk Aims:**
  - To illustrate application of POGIL concepts in the creation of a teaching resource
  - To enhance your confidence adopting in this pedagogical approach yourself

How to Plan for a POGIL Project

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- Decide on Objective
- Find a niche – how can your project fill a need
- Collaborate (Colleagues & Students)

Plan your project

- Target group, level, time limits, group sizes, resources, delivery
- Mystery / Challenge / “gamification”
- Timed & sequential building of skills & knowledge (supported)
- **Theme** – find a topic that captures attention
  - Genuine research links
  - Maintain theme for cohesion

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Theme & Niche - Heritage Science & Archaeology

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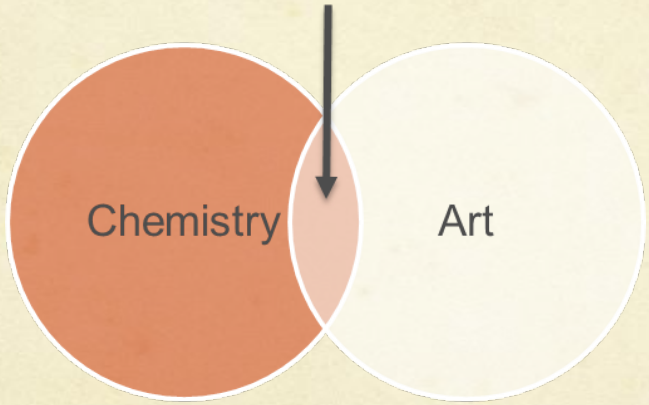
Important to find a **theme** that *supports the objective* and *unites all strands of project*.

Heritage Science: scientific methods and analysis of artefacts and works of art of cultural and historical significance

*"Heritage Science is an **interdisciplinary** research domain spanning the humanities and sciences"*



Archaeology - explores the nature of societies to understand social processes and how people make sense of their world through, eg. *Standing remains*

Theme: Roman Pigment Identification

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- **PPIP** and '**Cultural Chemistry**': non-destructive
- **Roman statuary**
- **Pigments** – bringing statues to life
- **Local traces** (Antonine Wall, Hadrians Wall)

Theme: Roman Pigment Identification

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- **Objective of PPIP**
  - Detection & analysis of pigment traces on Distance Stones
  - Use RAMAN and XRF to identify historic Roman pigments
- This information is used to re-imagine how objects originally appeared

Theme: Roman Pigment Identification

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- **NICHE:** These two techniques (RAMAN and XRF) are specific to analysis of inorganic compounds and underpin this project.
  - Genuine research
  - Clear links to AH Chemistry Curriculum (IR and elemental)
  - Engaging topic
- We have found both our **Theme** and our **Niche** with this collaboration.
- Our POGIL teaching unit was developed, ran for 100 minutes, and consists of two POGIL exercises designed to **support problem-solving skills**.
- Both use chemical techniques to determine "mystery" pigments in a problem-solving **"gamification"** approach

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POGIL in Action: Pigments & RAMAN

- We will explore one exercise: Raman Spectroscopy (a new concept)

  - Students work in small groups (3 max) to identify which of the painted stones on show corresponds to their “unique” set of information

  - Each group is given a “unique” set of RAMAN spectra

  - The groups are guided through the task, step-by-step, to reach the correct deduction

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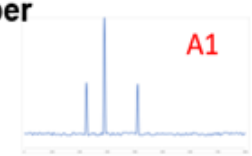
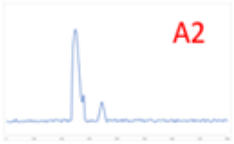
Raman Exercise: Overview

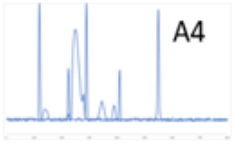
Step Number

1) 

→ Book of Raman. → Compound (pigment). → Predict Colour.

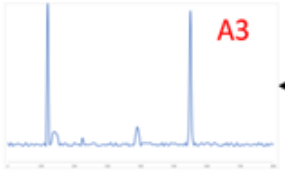
2) 

→ Book of Raman. → Compound (pigment). → Predict Colour.

3) 

→ Book of Raman. ✗ Observed that this spectrum is not in The Book of Raman.

↓

4) 

← **Problem solving**
Notice A4 = A1 + A2 + ??
Work out A3 via acetates.
A3 = ??

↓

5) A4 = A1 + A2 + A3 → Predict the colour of the mix. → Groups identify colour of rock they have. →  → Groups place group named pebble "correct" rock. → 

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Steps 1 & 2

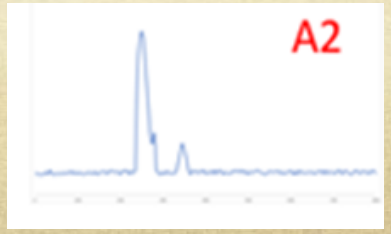
Step 1:

- Groups are given a Raman spectrum of an unknown pigment (on acetate)
- The spectrum is matched to one in “The Book of Raman”
- From this and the table at the front of the book, the **pigment is identified** as well as its **chemical composition** and **its colour**.

Fingerprint ***Database*** ***Identity*** ***Solve***

Step 2:

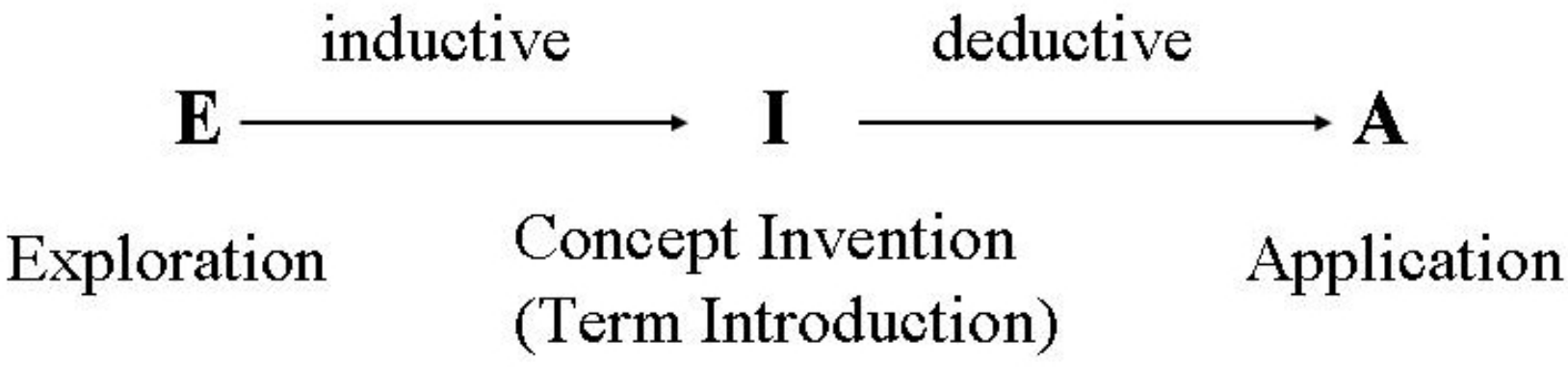
- The same procedure is repeated with a new Raman spectrum



Reasoning – Steps 1 & 2

- **Steps 1 & 2** both involve **processes** that the pupils must go through in order to develop their own **concepts** and **ideas** which is a major part of POGIL.

- **Step 1** is repeated in **Step 2** to allow the pupils to **build up confidence** and allow them to **teach them each other** rather than have a lecture.



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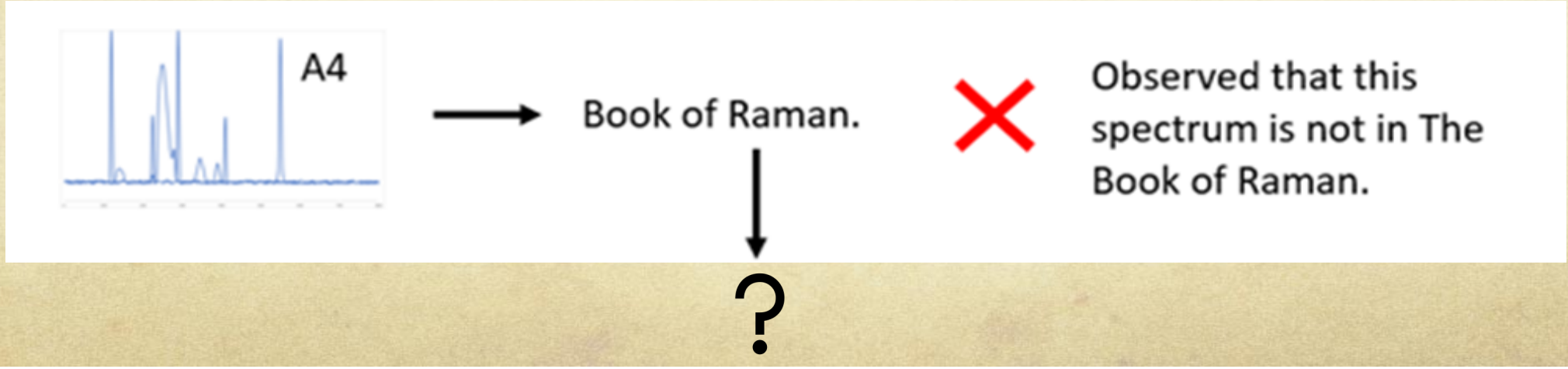
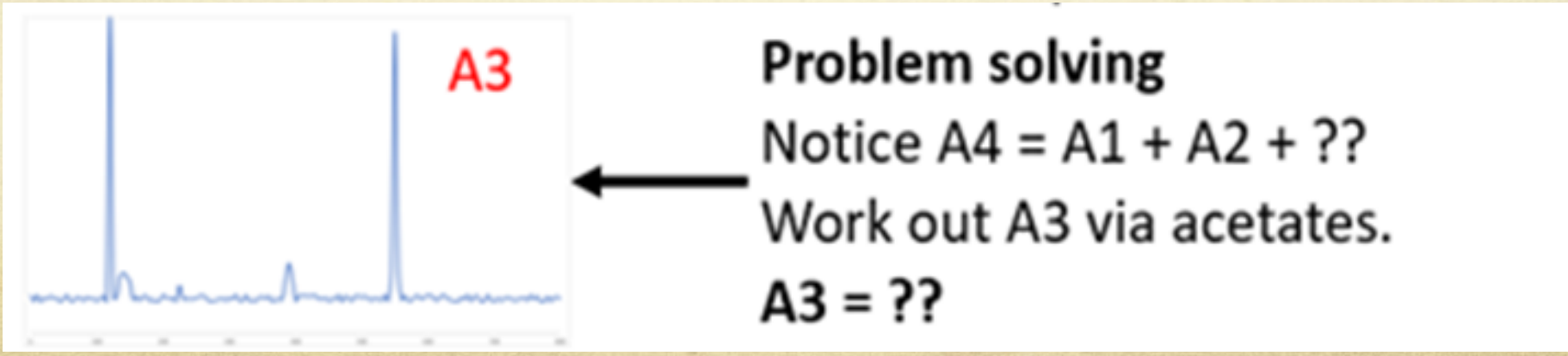
Step 3

- As for **Steps 1 & 2**, Groups are given a spectrum of an unknown pigment.
- This spectrum is much “messier” and “complicated looking”
- Pupils then follow the same procedure as before but soon realise the new spectrum does NOT match any in the Book of Raman.
- **What to do?**
- Need to complete a “retro-analysis” step as this spectrum is a mixture of 3



Step 4

- **How to solve the complicated spectrum?**
- Observation & Deduction that this is a combination of several spectra.
- Problem Solving: Pupils are given a blank acetate and a pen (as a hint) which allows them to trace out the third unknown pigment (by overlaying first two known spectra).
- Using this, and “The Book of Raman”, the third pigment, and its colour, is identified.



Reasoning - Steps 3 & 4

- A major part of POGIL is to develop **higher order critical thinking** by applying the previously learnt ideas to new concepts.

- The **team work** and **communication skills** of the groups is also improved as these steps will require:
  - **discussion** and **reasoning**
  - Both secondary aims of POGIL.

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Step 5 – Solving the Mystery

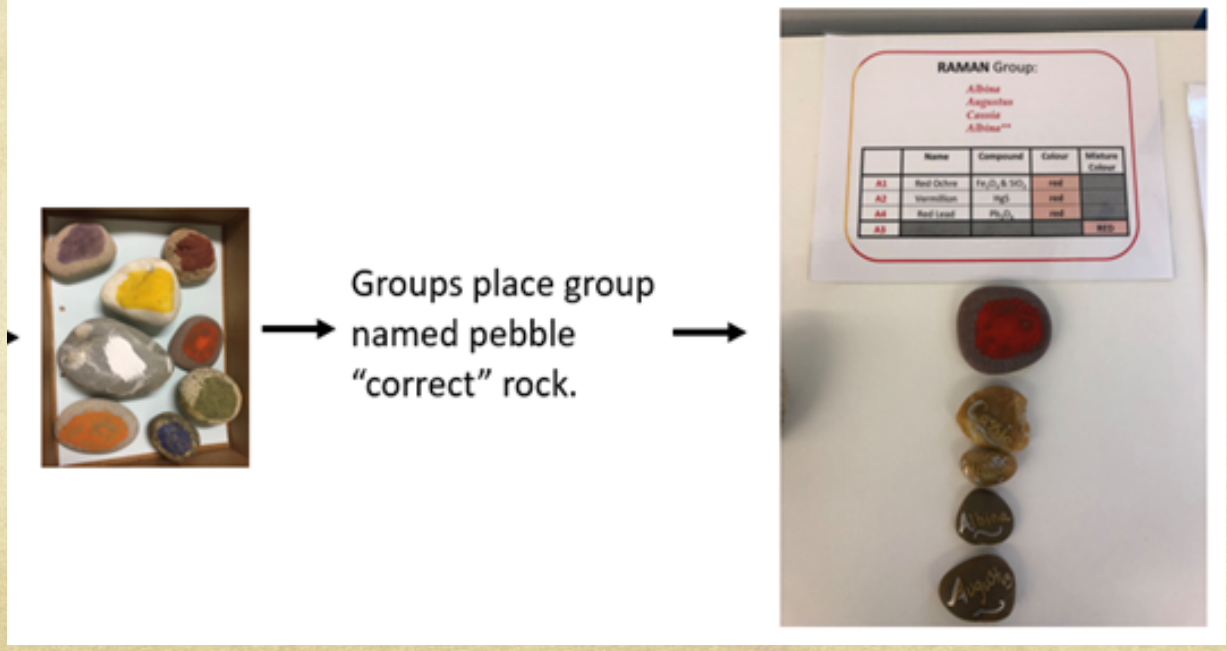
- By combining the colours of the **three** identified pigments, each group predicts the colour of their unique "mystery" ***pigment mixture***.
- Each group then identifies which of the selection of painted rocks is "theirs"
- The deductions are confirmed and discussed as a class to reconfirm the pathways used to achieve these outcomes.

Acetate

A4 = A1 + A2 + A3 → Predict the colour of the mix. → Groups identify colour of rock they have. →

Reasoning - Step 5

- This final step once again applying concepts to solve the final problem in a **“gamification”** approach.
- The final step of identifying the coloured stone **links back to the start** and gives the pupils and goal and **closure on the task**. This is a major part of POGIL.



Pilot & Feedback

- **Trialled** with 38 pupils and all feedback was very **positive**
- In the context of POGIL the main **STUDENT** outcomes were as follows.
  - Completely **new area** of Chemistry for students (37/38 students)
  - Improvement of **problem-solving skills** (28/38) and
  - Improvement of **communication skills** (28/38) as a result of the exercise.
  - **Enjoyed** the session (12/13 groups)
- **TEACHER** Feedback also very positive.
  - Greatly supported AH Chemistry curriculum, with positive implications for the exam...(unfortunately, not to be tested this year)

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Past, Present, Future and POGIL

- Successful demonstration of how POGIL can be used to support pupil curriculum ILOs, in this case analytical chemistry:
  - **Inorganic** Chemistry (RAMAN & XRF cf IR & elemental)(**Roman Pigments**, 2019-20)
  - **Organic** Chemistry (MS, IR, NMR, Elemental analysis)(**Mauveine**, 2018-19)
- This teaching unit is comprised of many resources (videos, teacher packs, student pack, guidelines) with the intention of providing this to teachers to run on their own.
- Successful cross-disciplinary collaboration
- The POGIL approach is applicable to other disciplines to create teaching units for all ranges of learner levels

Thanks & References

- An **enormous thank you** to the **LEADS L&T Conference Organisers** for their support in bringing this all together under exceptionally difficult circumstances!

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